

Memorandum

date: October 23, 2003

to: E. Lessard; Chair, LESHHC

from: Congwu Du, Micro-MRI Facility

subject: Summary of Responses to Safety Committee Comments

We thank the Committee for walking through the animal MRI facility on Sept 16, 2003, and giving us several valuable suggestions. We have carefully reviewed the questions the Committee raised during the walk-through, and our response is summarized below. We have also provided a summary of the actions and responses to recommendations made by the Committee as documented in the minutes of the August 25, 2003 meeting.

- 1. A cool-down, energize, shim and LOTO plan and schedule shall be written to cover the activities of J. Briske and any staff member he trains during his work time at BNL.***

The procedure for magnet installation includes pre-cooling the magnet using liquid nitrogen (LN₂), flushing the helium reservoir, cooling the magnet using liquid helium (LHe), energizing and superconducting shimming. Each procedure has been provided to the Committee and approved individually.
- 2. ODH calculations shall be documented and submitted to the LESHHC. The calculations shall be applicable to LN and LHe in the magnet room, and shall be relevant to filling and topping operations. The calculations need to address the magnet room and the hallway location where dewars are temporarily stored.***

BNL Safety and Health staff has conducted the ODH analysis for the nitrogen filling operation. Based on their recommendation, the room will be considered an ODH 2 level during the fill operation. An ODH analysis for normal operation has also been submitted to the committee. This analysis which assumes proper operation of the ventilation system classifies the magnet room as an ODH 0 space. This item will be independently reviewed and discussed further with the Committee.
- 3. Written procedures shall be written to assure that required ODH controls for normal and emergency conditions are in place. Procedures shall address access to the magnet room and adjacent rooms during the filling, energizing and topping tasks. Procedures shall address the keypad access for entrants into the magnet room, and key access into the magnet room. Procedures shall address ventilation requirements during filling, and when the magnet is cold. Procedures shall address response by the Animal MRI staff if the ventilation or ODH alarm system fails while the magnet is cold. Procedures shall address J. Briske's actions and staff actions should the magnet quench when the magnet is energized during acceptance testing. Procedures shall address required ODH controls and posting during filling operations, topping operations and whenever the magnet is cold. If the ODH calculations warrant, then a safety watch, escape packs***

and other pertinent ODH controls shall be addressed in the procedures. The written procedures for magnet installation have been provided by the Life Sciences Associate Laboratory Director, and approved by the Committee and Laboratory Management on September 17-26, 2003. All safety concerns regarding the installation, training, postings, access control, ventilation and protective equipment to be used during these procedures have been addressed in these written procedures. The emergency response has been included in these procedures as well.

Regarding the quench issue, if a quench occurs, all personnel who are working in the facility (including the Installation Engineer, Jim Briske) shall vacate the space immediately either to the hallway or by exiting the building. The exit door to the building 490 loading dock will be opened from outside to facilitate venting of the helium exhaust in the console room, where the O2 monitoring equipment (Bacarach Sentinal 44 O2, LEL Toxic) sensing O2 level in the magnet room (9-430C) is located. This allows authorized personnel to judge the safety for re-entering the magnet room according to the measurement. The procedure also requires a Health and Safety person to verify the oxygen levels prior to reentry by the research staff.

4. ***The fire run card for the Animal MRI suite shall be updated.*** This has been completed.
5. ***The fire alarm systems in the magnet room and power supply room shall be operable when the magnet is energized.*** They were operable when the magnet was energized.
6. ***ODH monitoring equipment in the magnet room must be tested and maintained operable while the magnet is cold.*** ODH monitoring equipment in the magnet room (Bacarach Sentinal 44 O2, LEL Toxic) has been calibrated and tested on Sept. 17, 2003. It has been working since then.
7. ***The electrical system used to energize the magnet must be reviewed and approved by T. Monahan.*** The electronic system used to energize the magnet is a Xantrex product. It has been tested and calibrated by the manufacturer on March 31, 2001. Magnex Scientific also has checked it before shipping it to the site. Both the certification of calibration and quality from Xantrex and the test sheet from Magnex Scientific are attached in Appendix 1. In addition, the Magnex Installation Engineer, Jim Briske double checked and calibrated the system according to the operating manual (attached in Appendix 2). T. Monahan inspected the electrical system before it was used to energize the magnet.
8. ***A procedure shall be written to perform a sweep of the magnet room for loose ferrous objects prior to energizing the magnet. The procedure shall address how the Animal MRI staff prevents entrants from bringing ferrous objects into the room when a magnetic field is present. The procedure shall include a requirement to perform magnetic field measurements during the time the magnet is energized. The procedure shall address control of whole-body and extremity magnetic field exposures of J. Briske and any trainees when the magnet is powered.*** The sweep of the magnet room for loose

ferrous objects has been performed before energizing the magnet. Also, postings have been used since energizing the magnet to warn persons with pacemakers, medical implants and loose ferrous metal objects.

Regarding the issue of the magnetic field exposures to the personnel after the magnet is energized. Jim Briske will be the only person exposed to the high field (about 8T in the back of the magnet) when he shims the system. The total cumulative exposure time is expected to be less than 20 hours. No trainees will be involved in this installation procedure. Following acceptance testing, the tenets of the Static Magnetic Field subject area will be followed for personnel safety and monitoring, including any periodic medical surveillance.

9. ***All procedures shall be reviewed and approved by the Medical Department. All personnel affected by the procedures shall be trained and their training records shall be maintained ready for audit.*** Presently the trained authorized personnel have been limited to Drs Du, Benveniste and Rooney, Bob Colichio, and Chris Harris who have been instructed to perform the top off cryogenic procedures. The procedure for cryogenic maintenance has been approved by the Medical Department and the Safety Committee.
10. ***Personnel who top off the magnet with LN and LHe after J. Briske leaves must be trained by J. Briske. Training documentation must define clearly what the trainee is allowed to do during the training. A procedure shall be written and it shall delineate precautions, PPE and the many steps necessary to perform the topping tasks. This procedure shall be reviewed and signed by T. Monahan in addition to being reviewed and approved by the Medical Department Chair.*** J. Briske has instructed the staff members, Drs. Congwu Du, William Rooney and Helene Benveniste in the correct procedure for topping off the cryogenics. The maintenance refill or “top off” procedure has been documented and approved.
11. ***J. Briske shall have all required BNL training, or acceptable equivalent, for the work he will perform at BNL.*** He passed the safety courses such as Cryogen web course.
12. ***W. Gunther shall explore and report on venting LN and LHe boil off into the helium quench pipe rather than the magnet room.*** As the boil-off rates for both of LHe and LN are designed to be very low (80cc/hour and 0.5 liter/hour, respectively) compared to the room ventilation rate, it is not considered a significant safety issue. However, Bruker provides this as a customer option so a work order has been submitted to Plant Engineering to have a fitting installed for this purpose. We expect the work to be completed in November 2003.

Comments and Questions as documented in the minutes of meeting 03-06 on August 25, 2003:

1. ***ODH Calculations need to be documented and submitted.*** ODH analyses are being rechecked by a Safety and Health representative. This will be provided to the Committee for comment.
2. ***Written procedures are needed to assure that required ODH controls are in place.*** Written procedures have been completed and approved by the Medical Department safety and management personnel. Additional procedures are planned to support normal operation of the facility and would include items such as forms for the daily instrument readings and facility specific training requirements, among others.
3. ***ODH Equipment must be tested and maintained.*** The oxygen monitoring and alarm equipment have been placed on a semi-annual calibration cycle. The ES&H Manager for Life Sciences is the owner of this procedure and process.
4. ***More information is needed on the BNL installed portion of the electrical and cryogenic systems.*** As part of the installation process, the supplier of the equipment (Bruker Biospin) will approve the entire installation. Plant Engineering worked very closely with Bruker during the design and construction activities associated with the facility so we do not anticipate any major changes.
5. ***A review of the vent piping needs to be completed.*** Plant Engineering used the specifications provided by Bruker to design and install the quench vent pipe system. As far as the quench vent sizing goes, Bruker's Specification T3N-1562 for the quench vent states in section C.2.c : "For a quench pipe possessing a total length shorter than 12 meters (39.37 feet) a tube with a cross-section of 15 cm (6 inches) is required. With these dimensions three 90 degree bends are possible. Other versions must be examined and approved by Bruker. The outlet construction must make it impossible for animals, birds, insects & snow to enter." What was installed was: 7.1 meters (23'-4"), plus three 90-degree elbows. Pipe has a cross-section of 15 cm (6"). The quench pipe is constructed of Schedule 10 - Type 304 Stainless Steel. All joints are welded. We will install an insect screen at the discharge end of the quench pipe. Prior to installation, John Coccoresse of Plant Engineering spoke with Jim Beier (National Service Manager for Bruker) to verify that our design was acceptable. John received a positive response from Jim.
6. ***A sub-committee will walk down the installation.*** Several members of the cryogenic subcommittee had a briefing and tour from Jim Briske, the Magnex Scientific field representative. Further tours and briefings will be arranged as requested by the Safety Committee.
7. ***The Cryo subcommittee needs more information on the design of the quench piping to ensure that it meets BNL expectations and satisfies manufacturer's recommendations.*** This is similar to item 5 above. Additional information will be solicited from Bruker if needed.

8. ***More information is needed on how the whole-body and extremity magnetic field exposures will be controlled. Procedures should document these requirements.*** A central component of the Small Animal MRI Instrument is a 9.4 T magnet manufactured by Magnex Scientific, Inc. This magnet is actively shielded which eases siting requirements because the spatial extent of the fringe magnetic field is greatly reduced. In fact, at BNL the 5 G field does not extend beyond the room that houses the 9.4 T magnet. Based on field plots supplied by the manufacturer it is expected that standard use of the 9.4 T Small Animal MRI instrument will result in worker whole-body static magnet field exposures of less than 600 G, and limb exposures less than 6000 G. Typically, workers will experience the greatest exposure when they are inserting, or removing an animal from the magnet. This exposure is expected to be brief, likely less than 60 minutes during a full day of experiments. The majority of the time workers will be in locations where magnetic fields are below 5 G. Therefore, it is expected that the time-weighted average will be far below BNL limits tabulated in the Static Magnetic Field Subject Area. It is possible that a worker could experience a limb exposure exceeding 5 T (a BNL ceiling limit for limb exposure); for example, if he or she were to reach a hand into the magnet bore. This is unlikely to be required during standard experimental procedures, but may be required during certain maintenance operations. In accordance with SBMS Static Magnetic Field Subject Area all users will be required to take Web-based Static Magnetic Field training, and high-magnetic field areas will be properly posted. Individuals that experience magnetic field exposures that exceed BNL time-weighted average or ceiling limits will document their exposure in a log book (that includes exposure date, individual's name, duration of exposure, and estimated field strength). This logbook will be maintained at the console of the Small Animal MRI Instrument. Following the activation of the magnet, measurements of the magnetic field will be made to verify the calculations and to mark the floor of the room with the actual distribution.
9. ***Noise measurements need to be conducted by SHSD to assure a proper hearing protection program and postings. A review of the RF system (400MHz, up to 1 Kw) needs to be conducted to assure that RF exposures are within those allowed by BNL SBMS. Procedures need to specify if controls are needed to prevent overexposure to RF.*** These measurements will be taken once the installation is completed.
10. ***Training of Users who conduct "hands on" experiments needs to be documented.*** Facility specific training will be defined and required prior to allowing access to outside users.
11. ***Assurance is required to show that adequate instrumentation is available to allow monitoring of critical parameters of the MRI facility.*** Flow instrumentation to better monitor boil off rates has been ordered and will be installed prior to final commissioning. Safety related instrumentation (oxygen readout unit) has been installed and verified to be operable and in calibration. Training that remains to be conducted by Bruker may identify other instrumentation that would be desirable to monitor and log regularly.

12. ***Written procedures that incorporate manufacturer's generic maintenance and operations instructions into BNL specific procedure steps need to be written.*** The maintenance procedure has been written and approved.
13. ***Specific frequencies for maintenance and testing of all sub-systems need to be established.*** The frequencies for nitrogen and helium fills are dictated by the amount of boil-off that occurs. The calibration of other instrumentation will be as stipulated by the manufacturer or as recommended by Bruker.
14. ***The MRI manufacturer should have all required BNL training, or acceptable equivalent, for the work that will be performed by them at BNL.*** The service representatives that have been provided thus far by Magnex and Bruker have been experienced personnel who have significant training in their areas. This has been supplemented by BNL Training (contractor and/or cryogen safety training). In addition, we have maintained a presence of authorized BNL people while the service personnel are performing any work within the magnet room.

C:

H. Benveniste
W. Gunther